

The background of the slide is a photograph of the interior of the KamLAND detector. It shows a large, spherical structure composed of many triangular panels. Each panel is covered with numerous small, circular photomultiplier tubes (PMTs) that are illuminated, creating a grid of bright points. A yellow, segmented tube, likely part of a maintenance or access system, extends from the bottom left towards the center of the sphere. The overall lighting is dim, with the primary light source being the PMTs themselves.

KamLAND

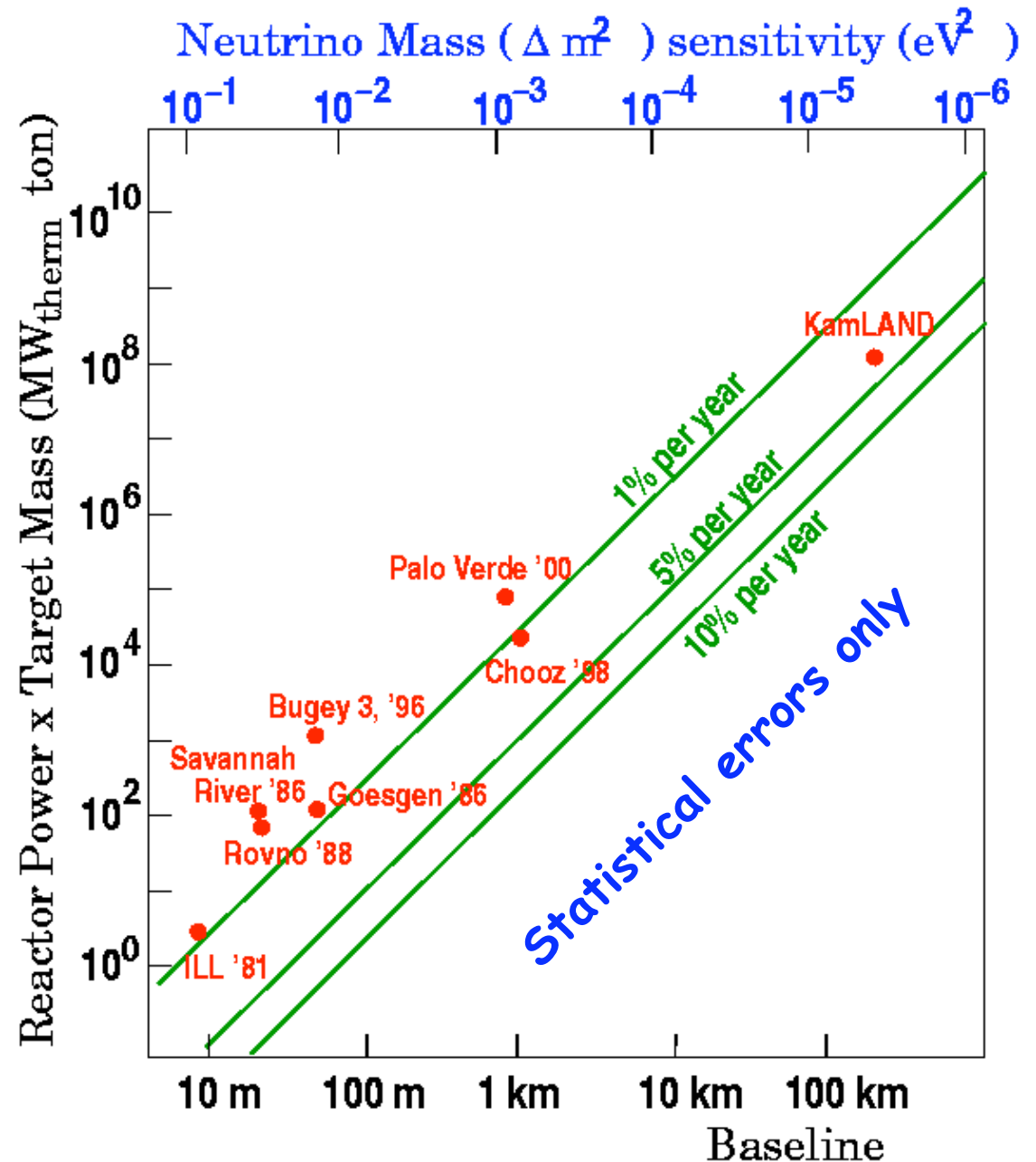
October 11, 2002

Status of KamLAND

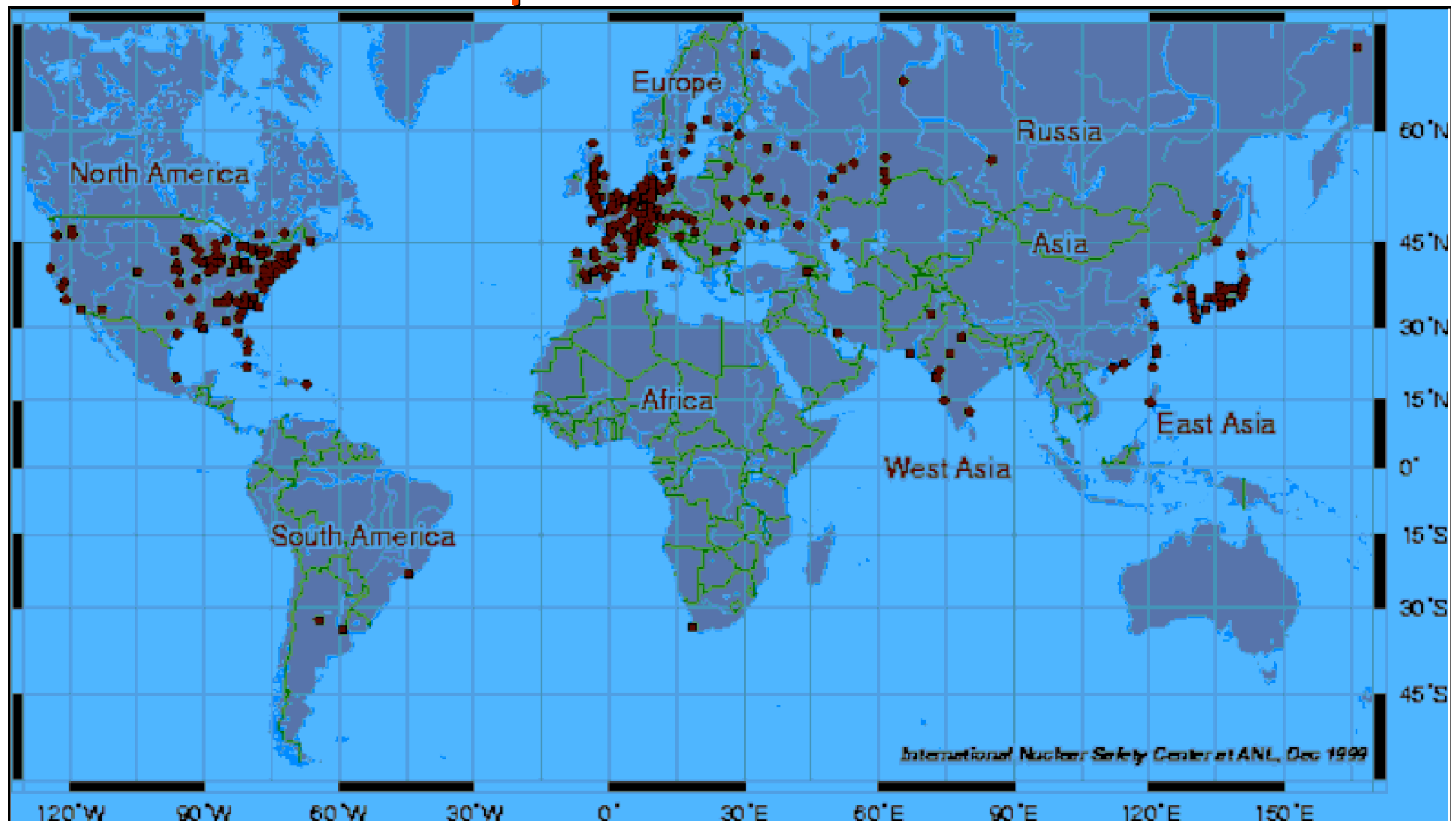
Presented by Glenn Horton-Smith (Caltech)
for the KamLAND collaboration

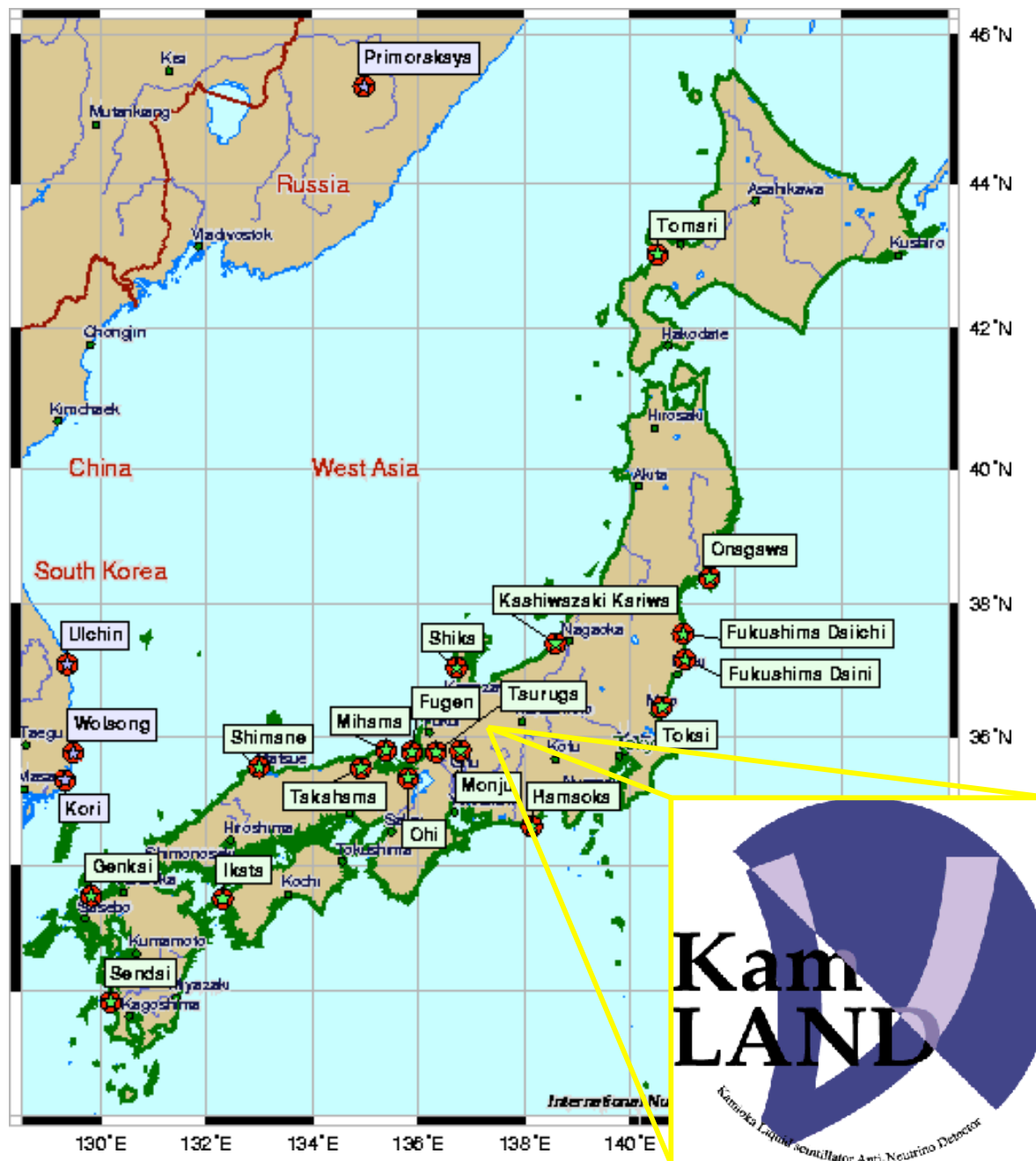
Designed to
test solar neutrino
oscillation parameters
on Earth (!)

KamLAND has a much
longer baseline
than previous
(reactor) experiments
*...still quite a
difficult experiment*



Only a few places in the World could host
an experiment like KamLAND...





Oct 11, 2002

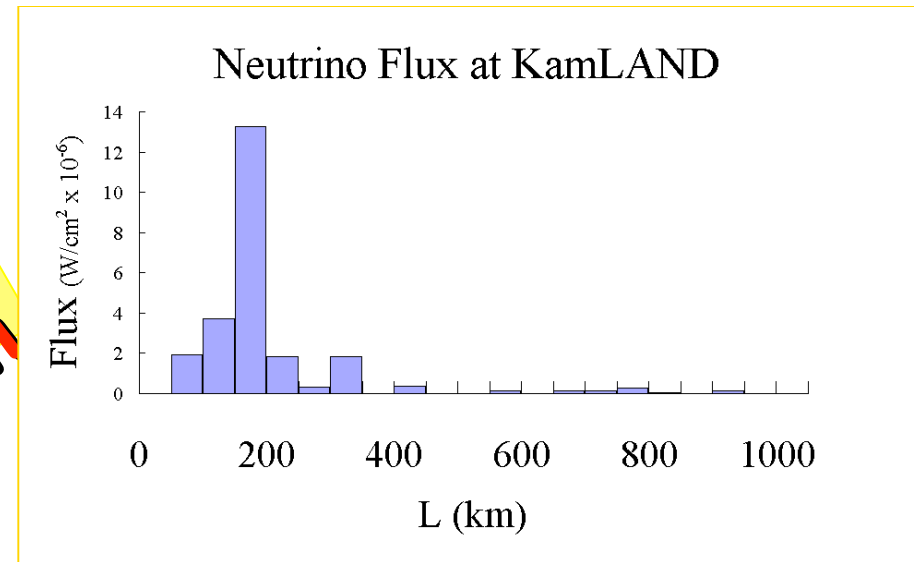
KamLAND Status

Site	Distance	# of	P(ther.)	flux	Signal
	(km)	cores	(GW)	($\bar{\nu}$ cm ⁻² s ⁻¹)	($\bar{\nu}$ /yr)
Japan					
Kashiwazaki	160.0	7	24.6	4.25x10 ⁵	348.1
Ohi	179.5	4	13.7	1.88x10 ⁵	154.0
Takahama	190.6	4	10.2	1.24x10 ⁵	101.8
Hamaoka	214.0	4	10.6	1.03x10 ⁵	84.1
Tsuruga	138.6	2	4.5	1.03x10 ⁵	84.7
Shiga	80.6	1	1.6	1.08x10 ⁵	88.8
Mihama	145.4	3	4.9	1.03x10 ⁵	84.5
Fukushima-1	344.0	6	14.2	5.3x10 ⁴	43.5
Fukushima-2	344.0	4	13.2	4.9x10 ⁴	40.3
Tokai-II	294.6	1	3.3	1.7x10 ⁴	13.7
Shimane	414.0	2	3.8	9.9x10 ³	8.1
Onagawa	430.2	2	4.8	9.8x10 ³	8.1
Ikata	561.2	3	6.0	8.4x10 ³	6.9
Genkai	755.4	4	6.7	5.3x10 ³	4.3
Sendai	824.1	2	3.3	3.5x10 ³	2.8
Tomari	783.5	2	5.3	2.4x10 ³	2.0
Korea					
Ulchin	~750	4	11.2	8.8x10 ³	7.2
Wolsong	~690	4	8.1	7.5x10 ³	5.2
Yonggwang	~940	6	16.8	8.4x10 ³	6.9
Kori	~700	4	8.9	8.0x10 ³	6.6
Total		69	175.7	1.34x10⁶	1102

**Total expected signal
from reactors:
≈2 ev/day**

**S/N ratio ≈ 20
@ 10⁻¹⁴ U, Th, ⁴⁰K
contamination in
the scintillator**

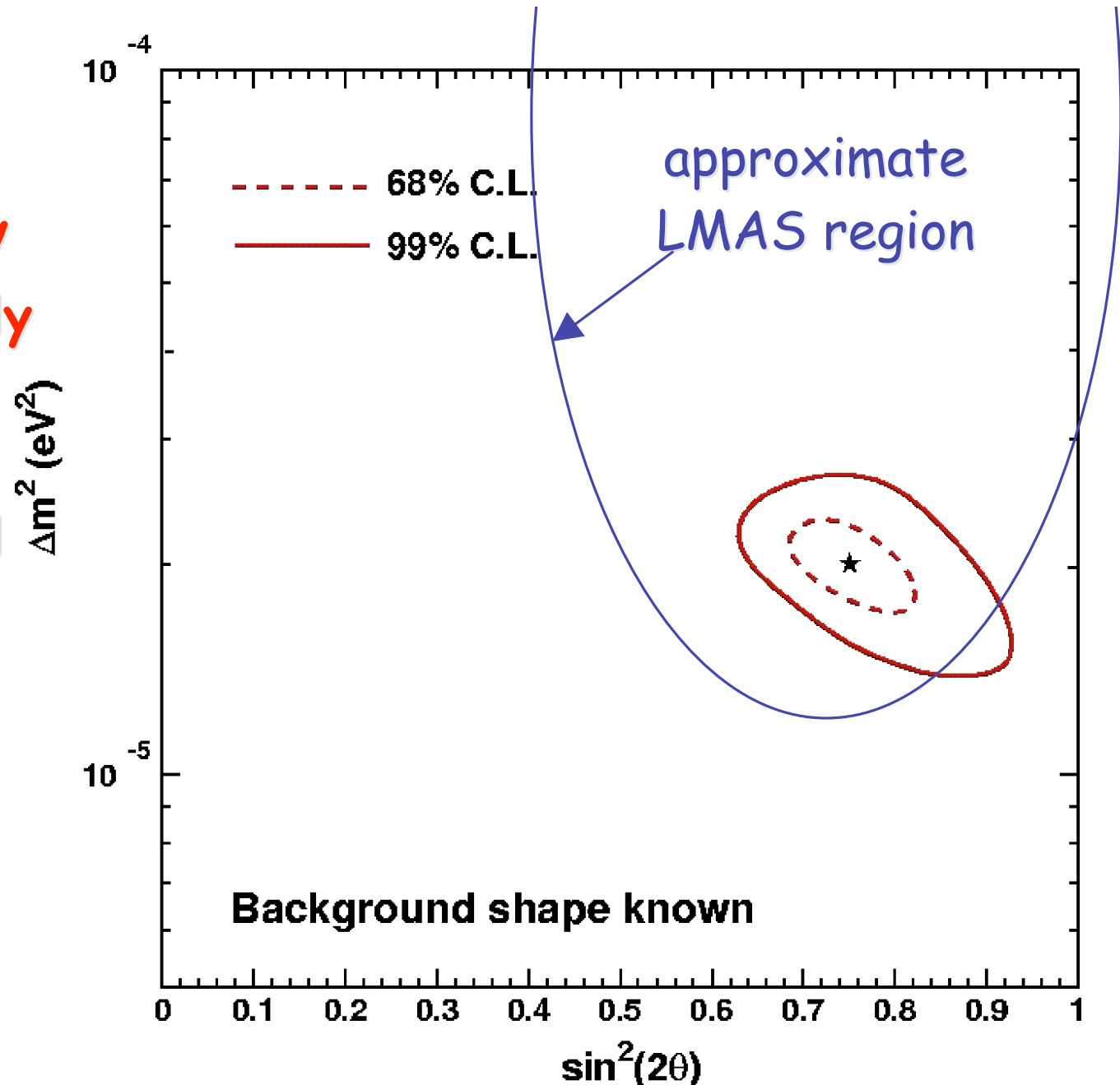
**Baseline is limited:
85.3% of signal has
 $140 \text{ km} < L < 344 \text{ km}$**



The total electric power produced "as a by-product" of the s is:

- ~60 GW or...
- ~4% of the world's manmade power or...
- ~20% of the world's nuclear power

The ability to
measure the
solar LMA-MSW
solution accurately
"in the lab"
puts KamLAND
in a very special
category of
experiments



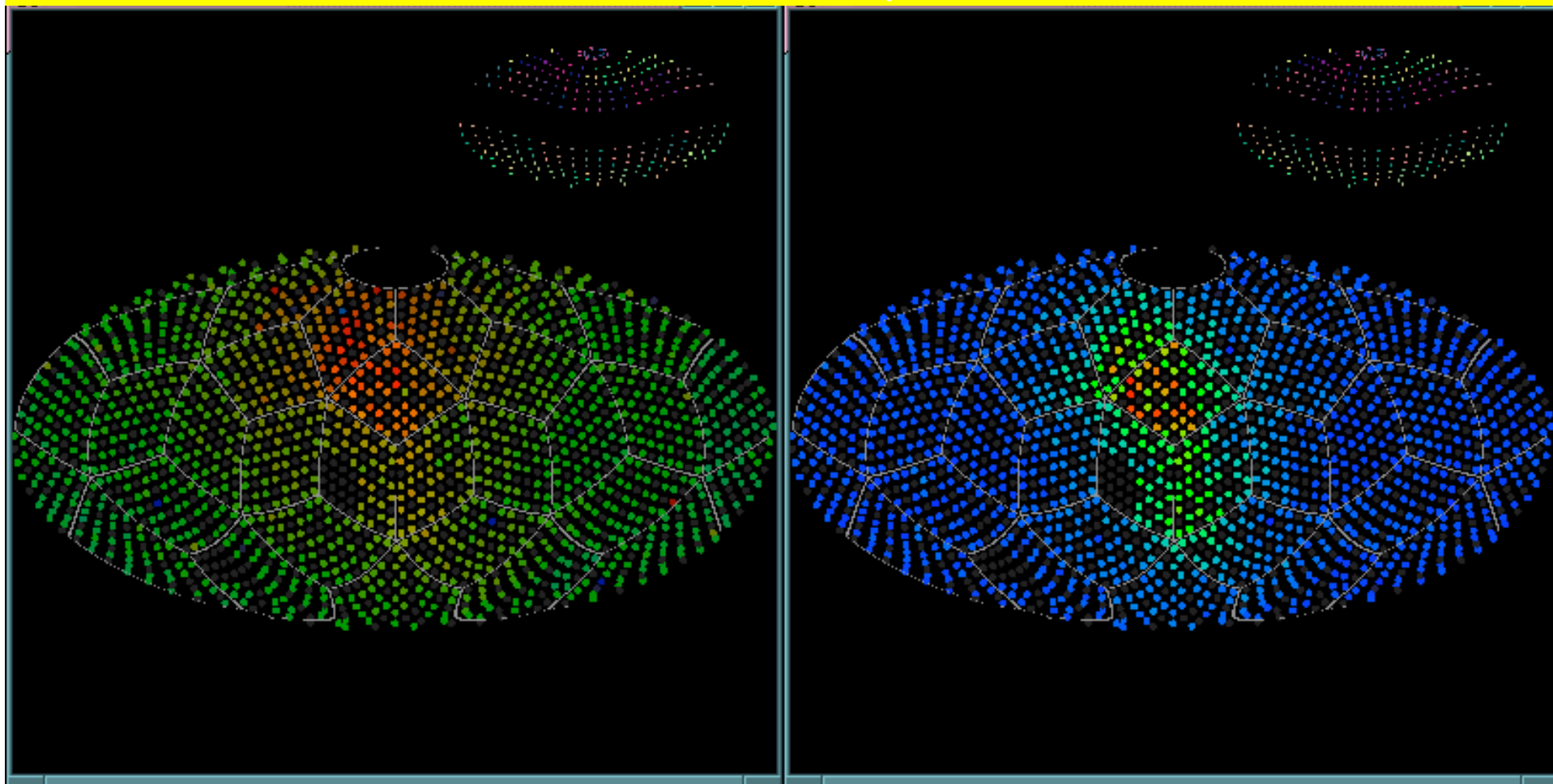
Other initial physics topics include:

- Geological neutrinos
- Supernovae detection
- Solar anti-neutrinos
- Exotic nucleon decay modes

KamLAND: neutrino physics on a shinkansen

•Summer 2000	PMT installation
•Winter 2000-01	Veto counter installation
•Feb 2001	Balloon insertion
•Mar-Apr 2001	Balloon inflation and test
•Apr-May 2001	Plumbing for fill
•Jun-Sept 2001	Fill MO and LS
•Aug-Sept 2001	Eng. runs with Macro Elec.
•Sept 2001	FEE/DAQ/Trigger int. (LBL)
•end Sept 2001	First data taking with FEE
Oct 11, 2002	KamLAND Status
•Jan 22, 2002	Begin Data Taking

First muon events, Jan 2002



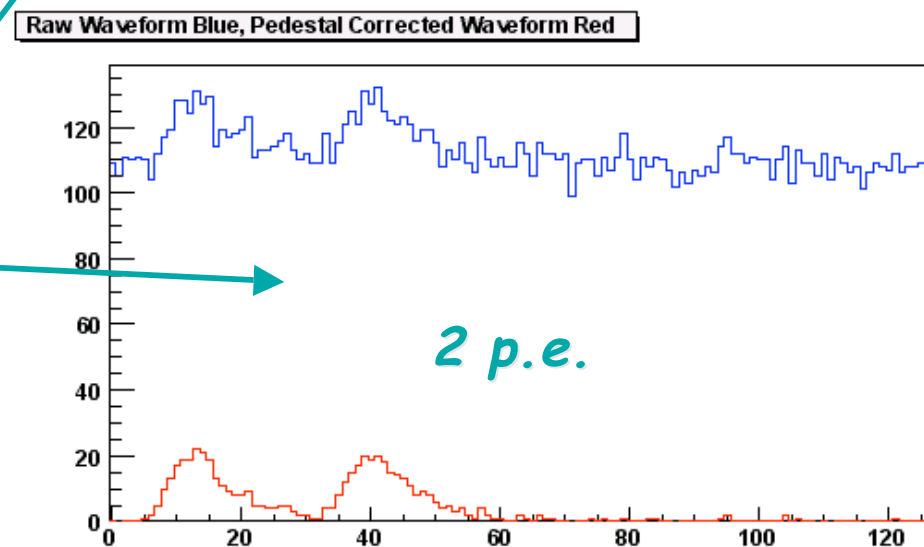
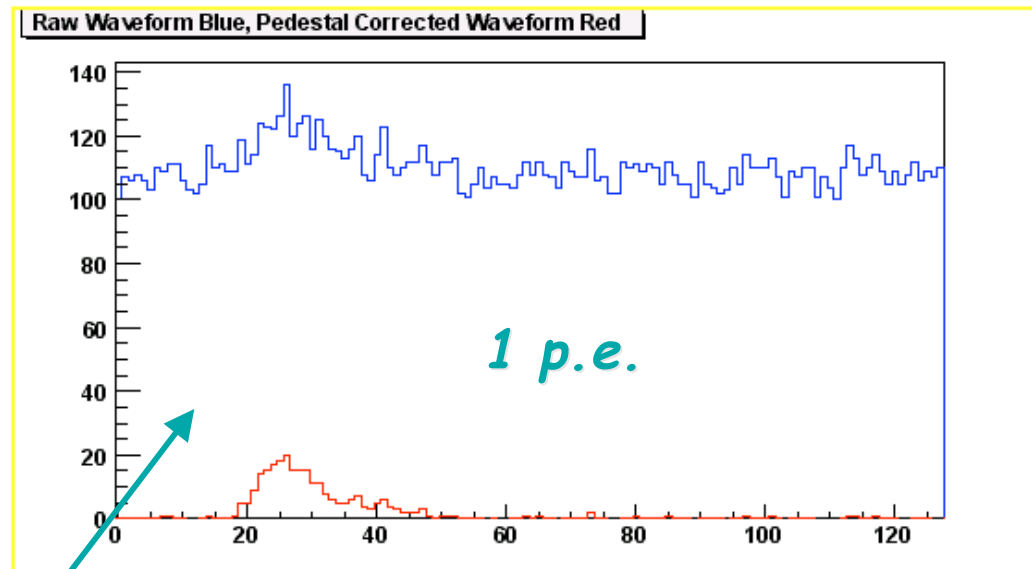
Time: **Red** soon, **Blue** late

Charge: **Red** alot,
Blue little

Have full waveform
digitizers on every
central and veto
channel

Very important for
exploring new physics
and reject complex
background signatures

*Signals from blue LED
flashers in the detector*



KamLAND Event Display

Run/Subrun/Event : 110/0/1907

UT: Sat Feb 23 15:16:54 2002

TimeStamp : 3416793063

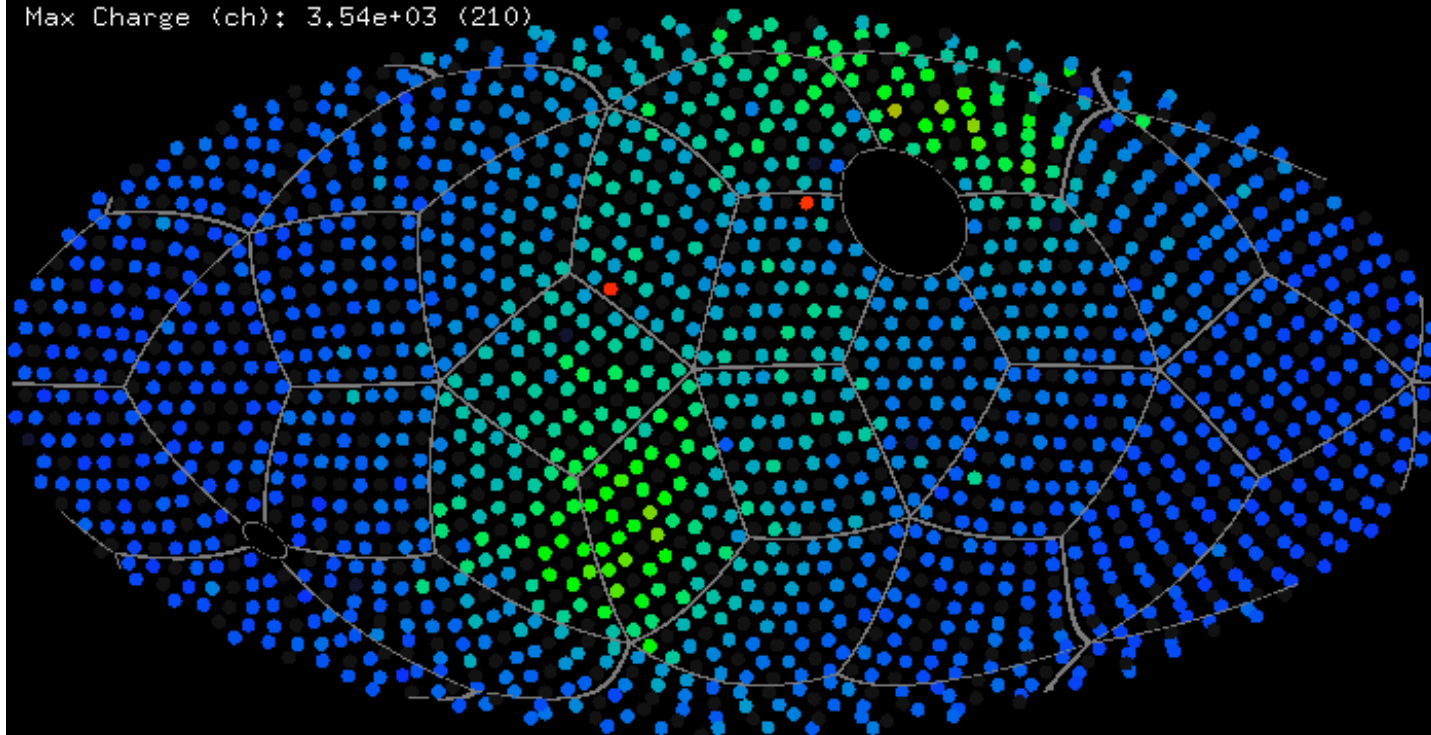
TriggerType : 0x7210 / 0x2

Time Difference 10.1 msec

NumHit/Nsum/Nsum2/NumHitA : 1315/199/1327/77

Total Charge : 9.02e+05 (1.17e+03)

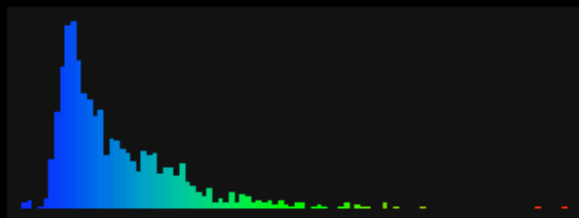
Max Charge (ch): 3.54e+03 (210)



through_going
muon

color is
pulseheight

all tubes
illuminated



Q : 83.2 428.6 774.1 1119.5 1465 1810.4 2155.8 2501.3 2846.7 3192.1 3537.6

KamLAND Event Display

Run/Subrun/Event : 110/0/19244

UT: Sat Feb 23 15:25:11 2002

TimeStamp : 13052924536

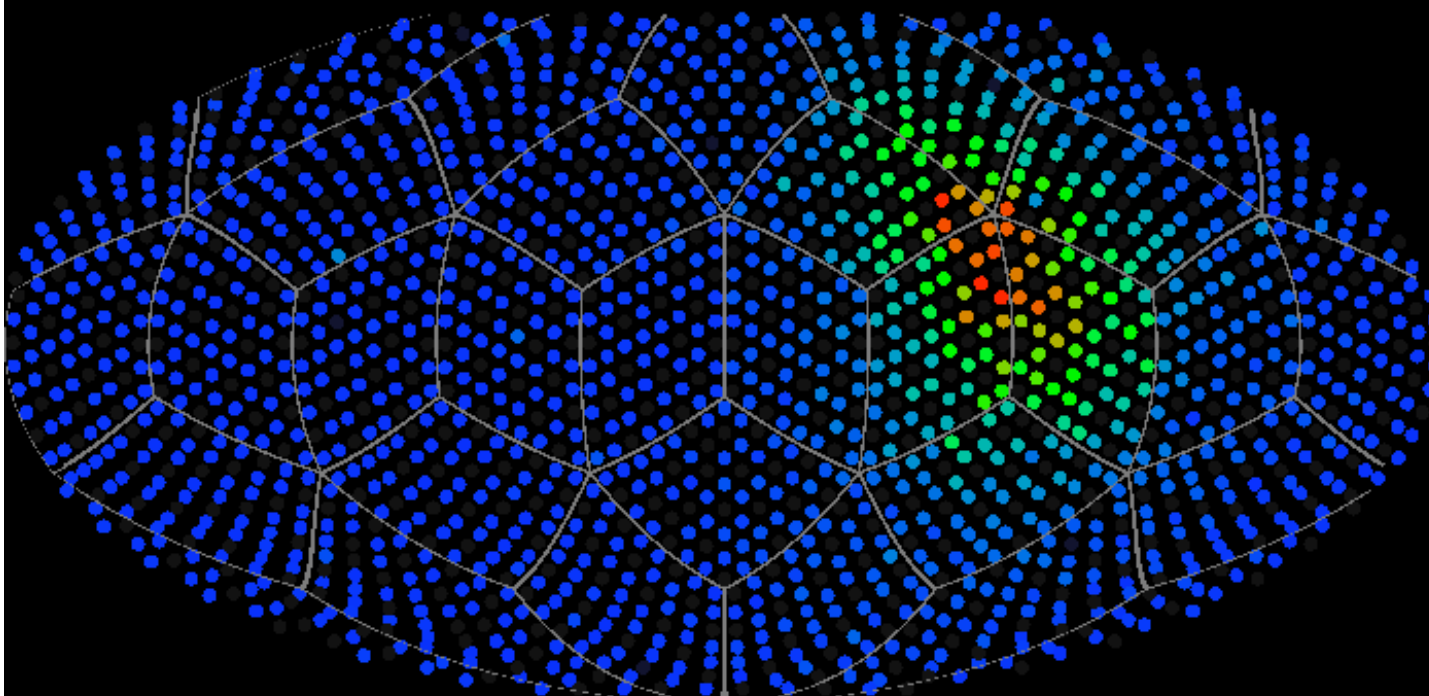
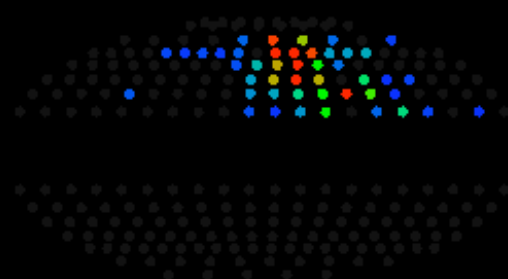
TriggerType : 0x3a10 / 0x2

Time Difference 28.3 msec

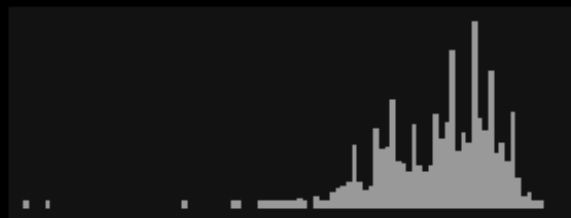
NumHit/Nsum/Nsum2/NumHitA : 1317/264/1322/46

Total Charge : 3.21e+05 (465)

Max Charge (ch): 2.22e+03 (640)



Stopped muon



Q : 0.4 222.3 444.1 665.9 887.7 1109.5 1331.3 1553.2 1775 1996.8 2218.6

KamLAND Event Display

Run/Subrun/Event : 110/0/91185

UT: Sat Feb 23 15:57:50 2002

TimeStamp : 53000002993

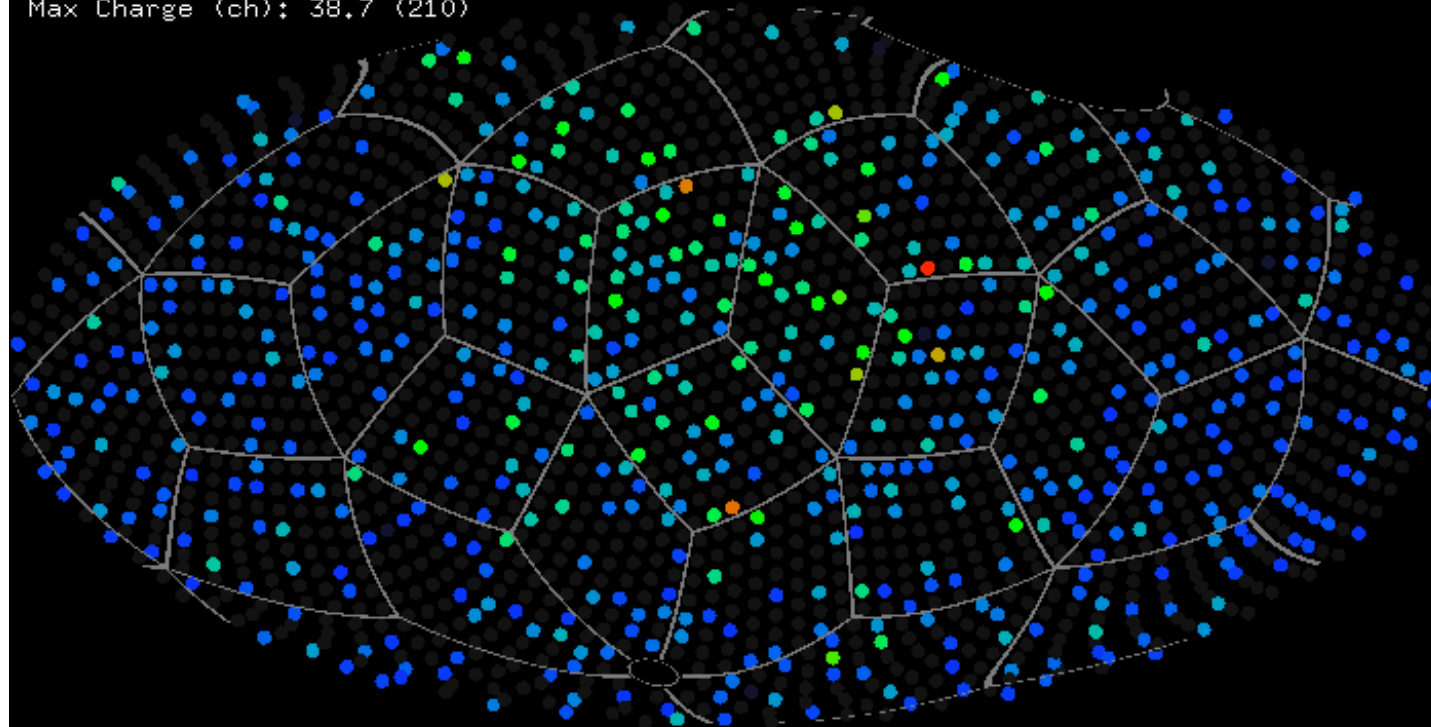
TriggerType : 0xb00 / 0x2

Time Difference 925 nsec

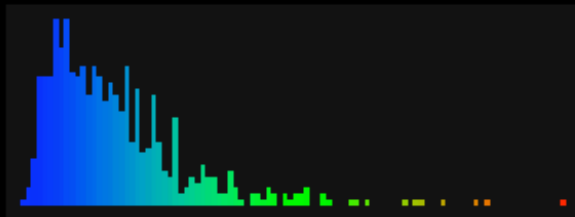
NumHit/Nsum/Nsum2/NumHitA : 585/466/1071/0

Total Charge : 4.12e+03 (0)

Max Charge (ch): 38.7 (210)



...decaying into
a Michel electron



Q : 0.2 4 7.9 11.7 15.6 19.4 23.3 27.1 31 34.8 38.7

KamLAND Event Display

Run/Subrun/Event : 110/0/3772

UT: Sat Feb 23 15:17:50 2002

TimeStamp : 4363651980

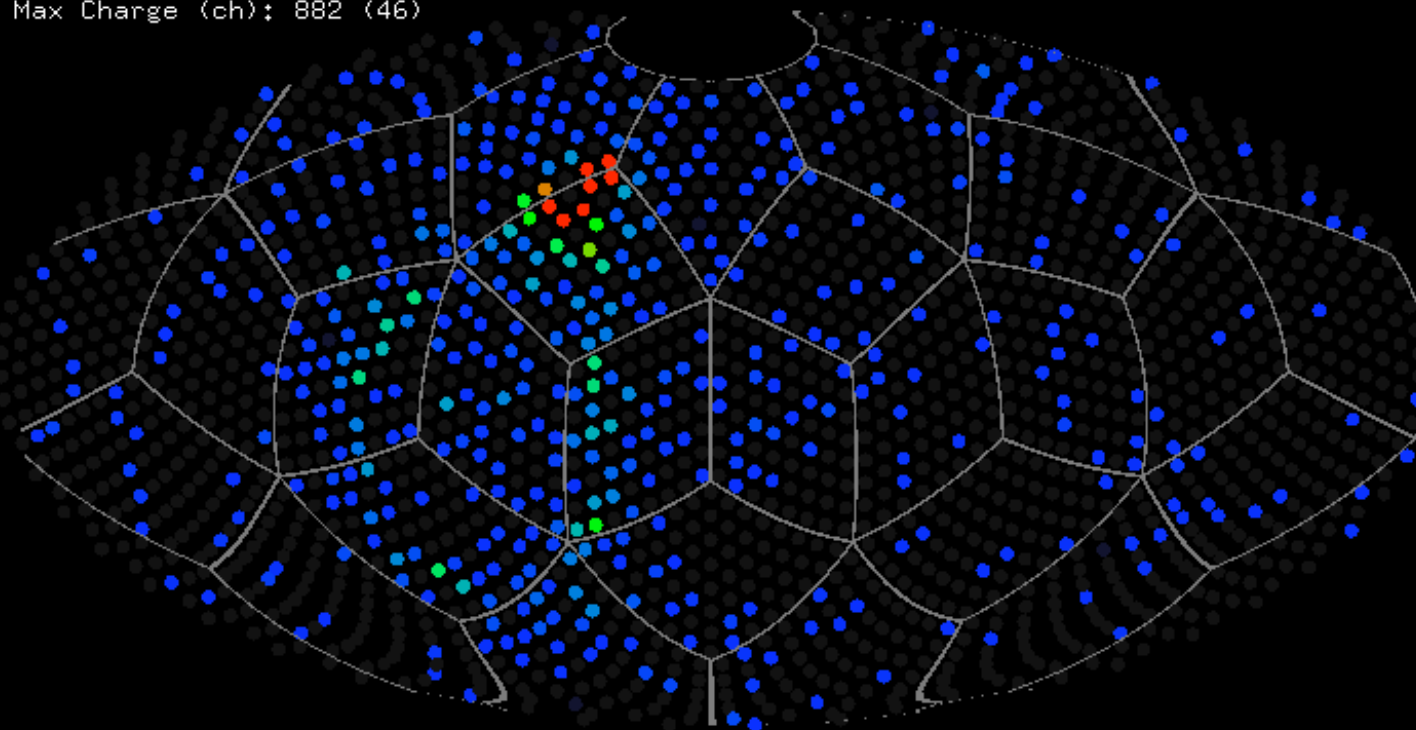
TriggerType : 0x3210 / 0x2

Time Difference 4.13 msec

NumHit/Nsum/Nsum2/NumHitA : 468/177/427/45

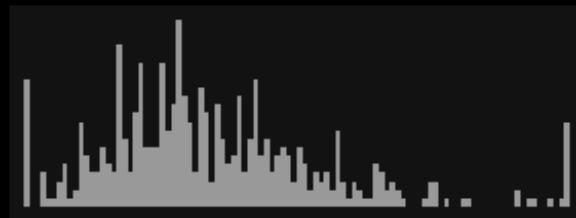
Total Charge : 3.05e+03 (471)

Max Charge (ch): 882 (46)



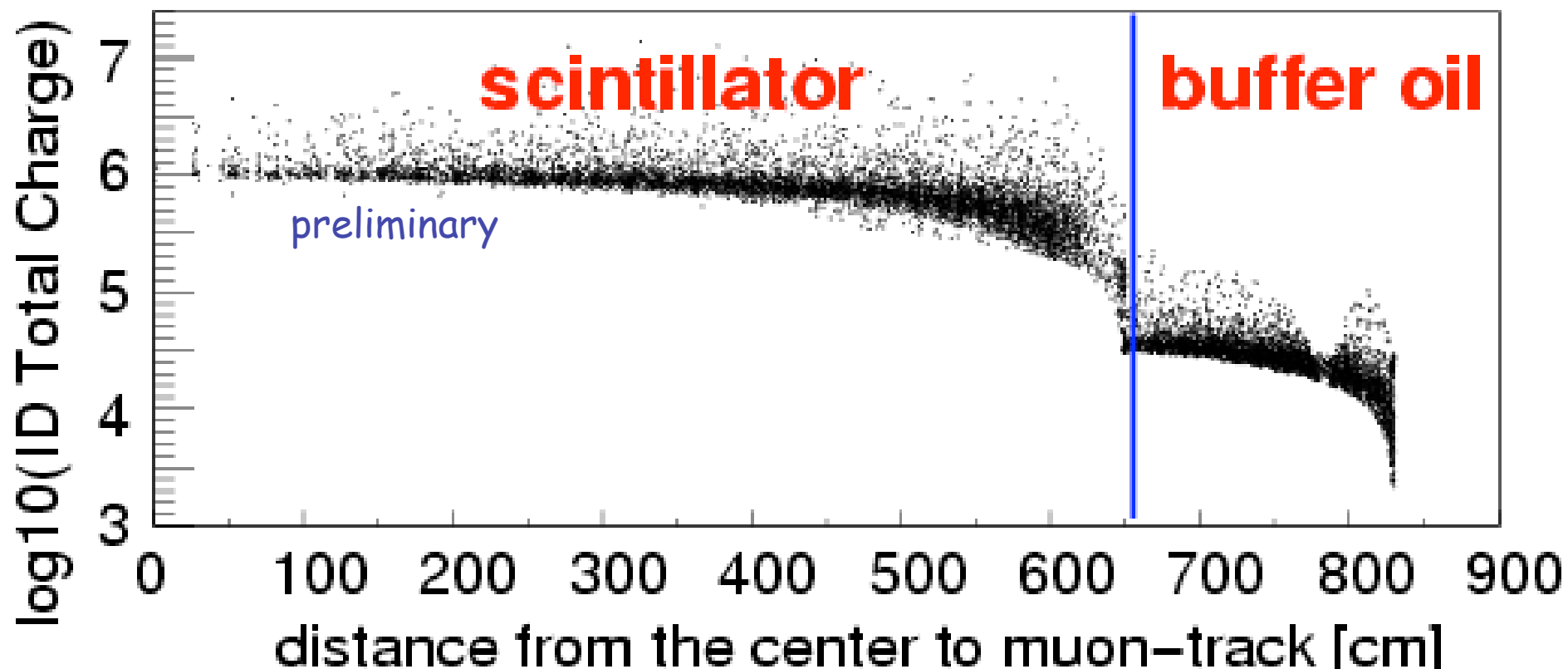
Corner-clipper
muon:

*Cherenkov
ring in the
buffer but
no scintillation
activity*

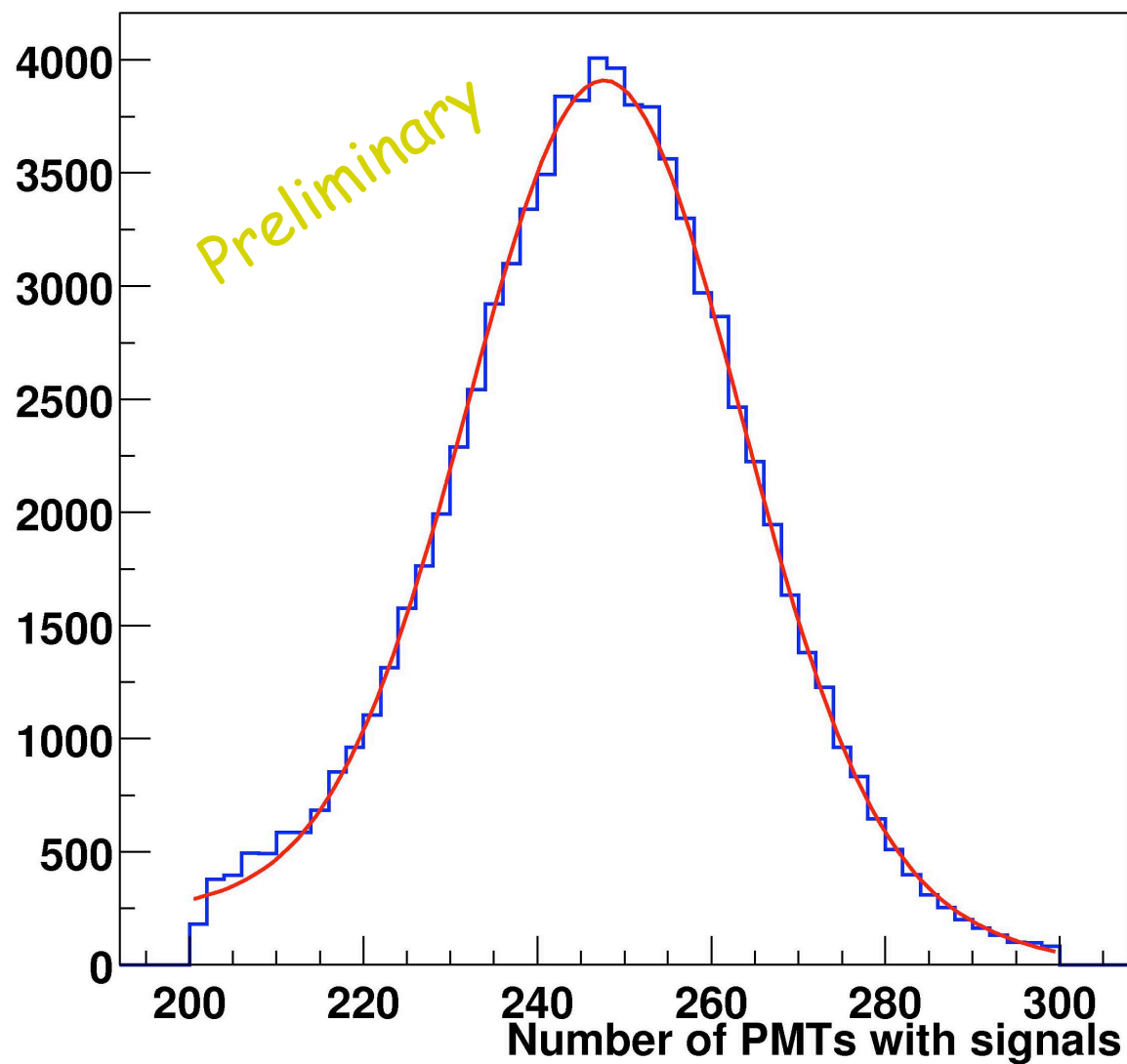


Q : 0.1 4.3 8.5 12.7 16.9 21.2 25.4 29.6 33.8 38 42.2

Muon track reconstruction reveals the balloon boundary and the different light yield in scintillator and buffer oil (cherenkov)

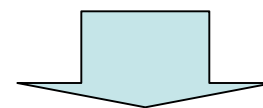


Zn65 At Center Of Detector



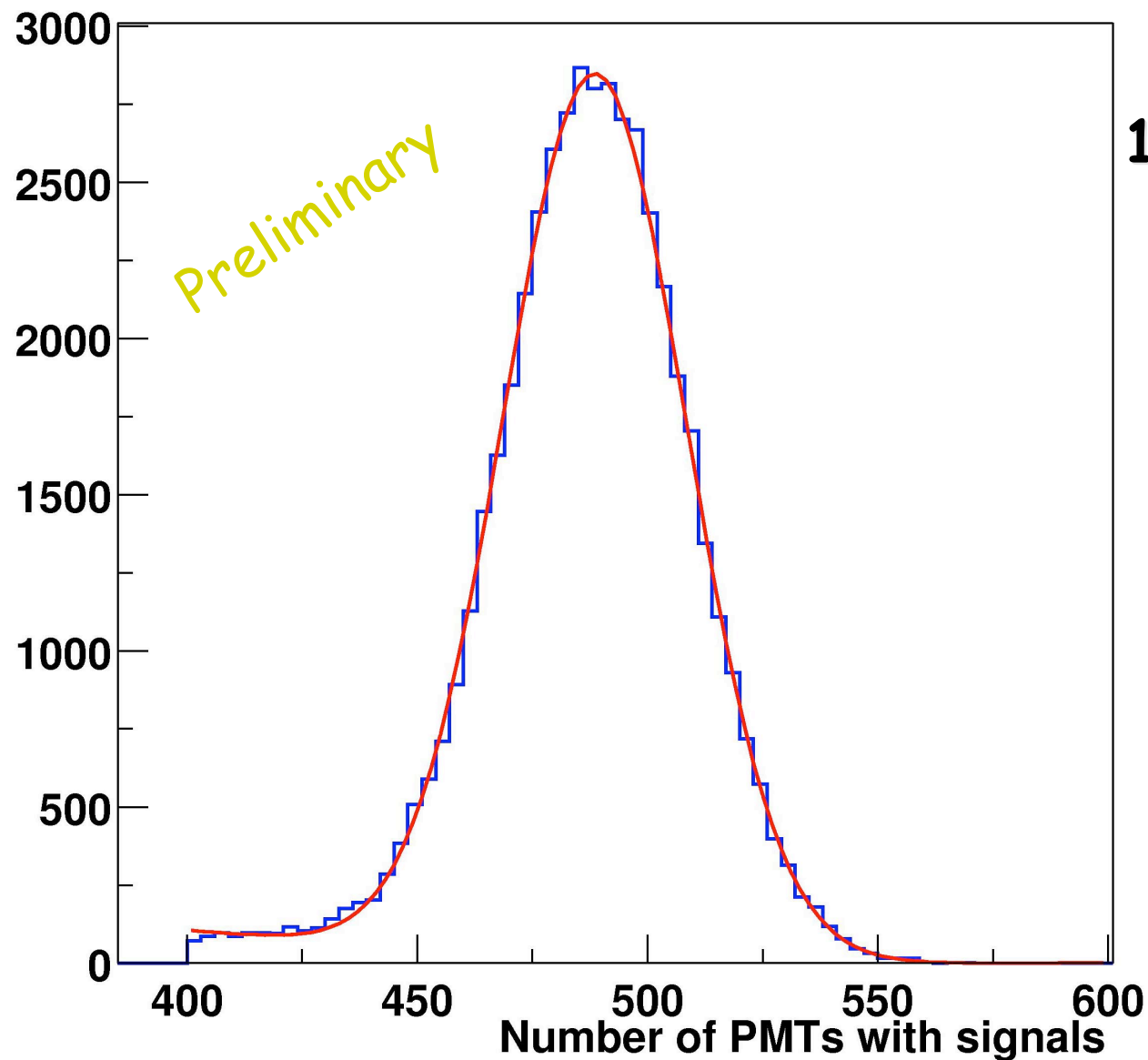
^{65}Zn :
1.115 MeV in
the detector

$$\sigma/E = 6.5 \%$$



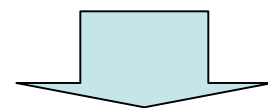
Light Yield
241 p.e./MeV

Co60 At Center Of Detector



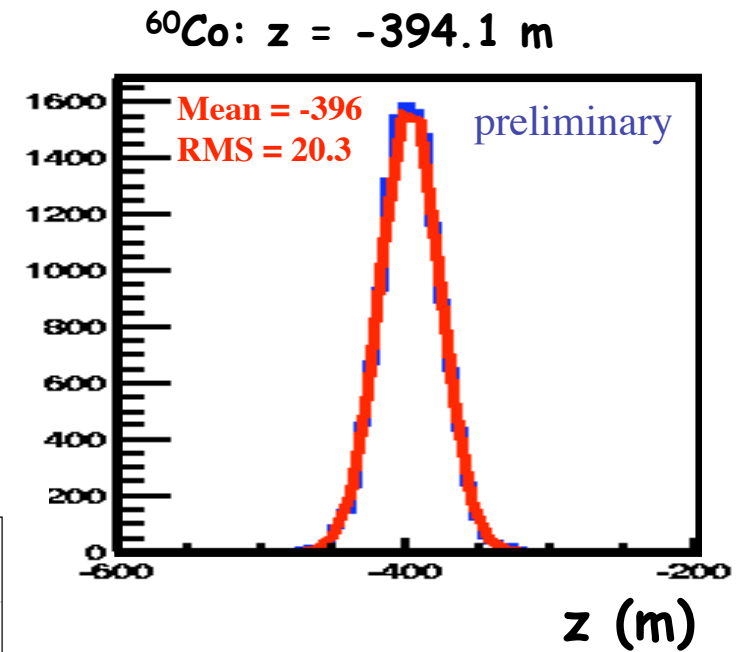
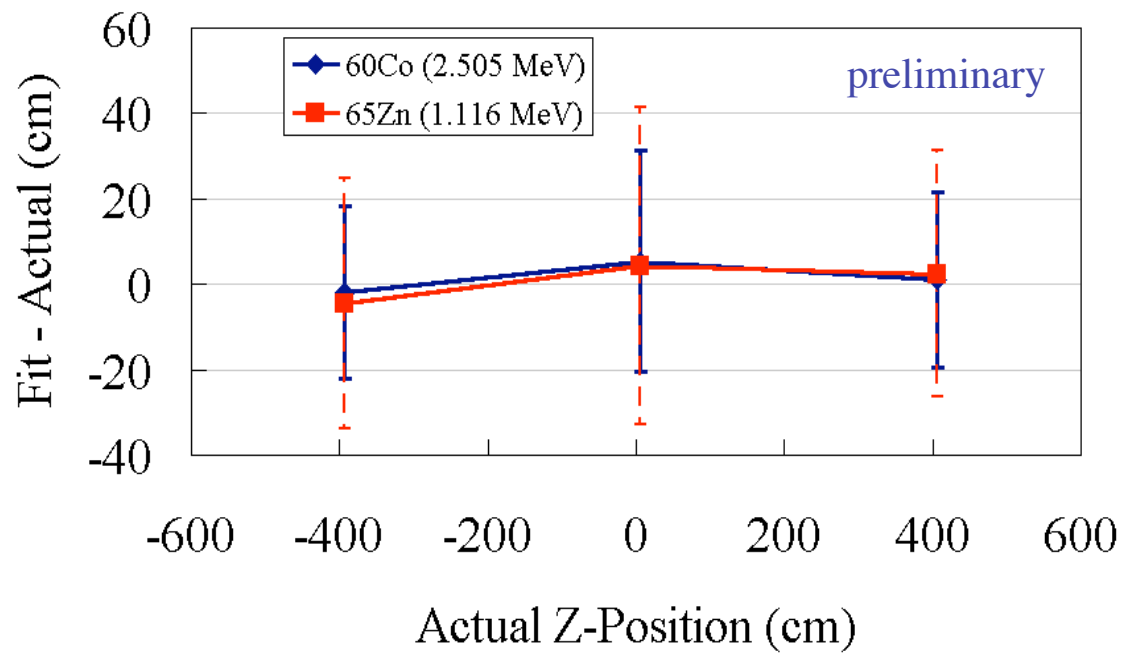
^{60}Co :
1.173+1.333 MeV in
the detector

$\sigma/E = 4.2\%$

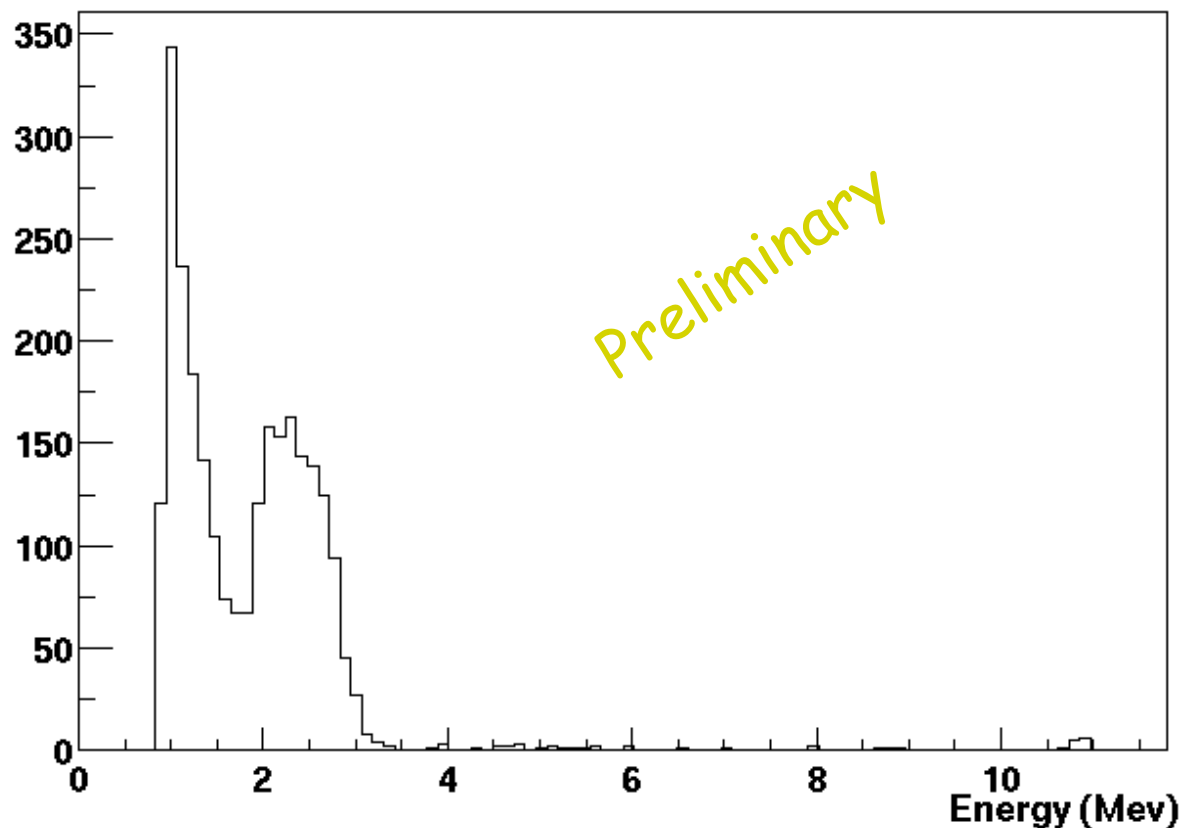


Light Yield
239 p.e./MeV

Position Calibration



Now find cosmic ray muons traversing the detector
and look for energy deposits following them



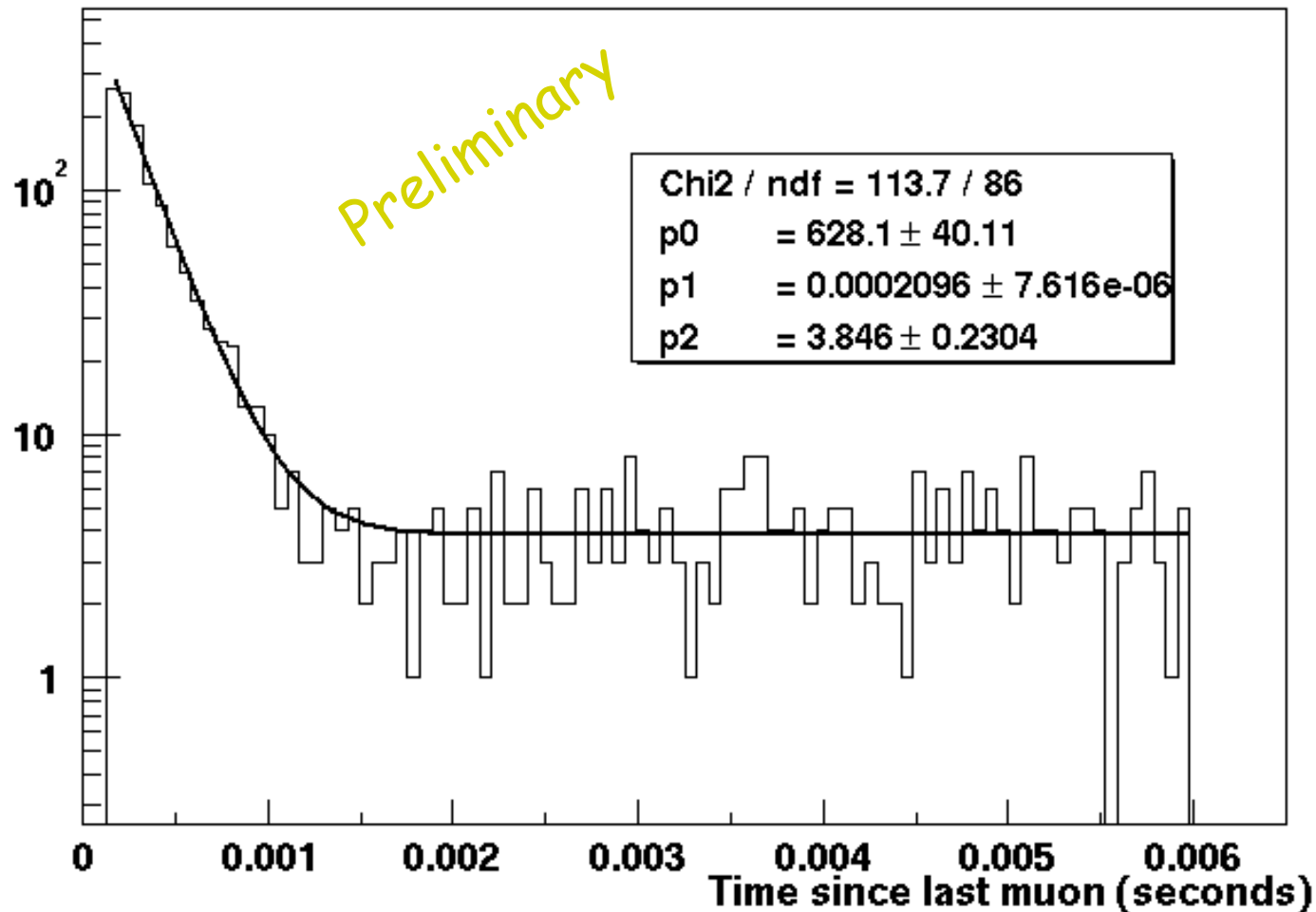
Using E cal.
from previous
slide the peak
is here at
 $\approx 2.3 \text{ MeV}$

n-capture in
hydrogen gives
 2.2 MeV

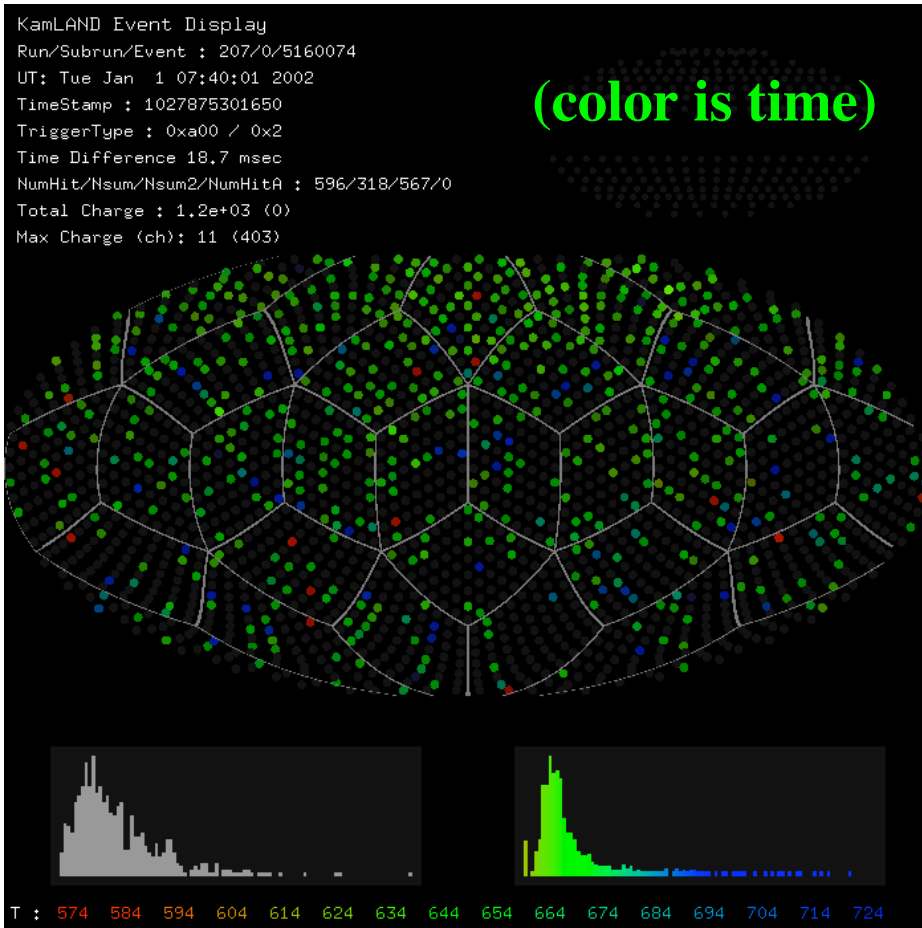
Prompt - delayed correlation time distributed
as an exponential with 210 ± 8 μ s

Expectation for neutron capture is ~ 223 μ s

Neutrons Following Muons ($300 < n_{\text{sum}} < 600$)

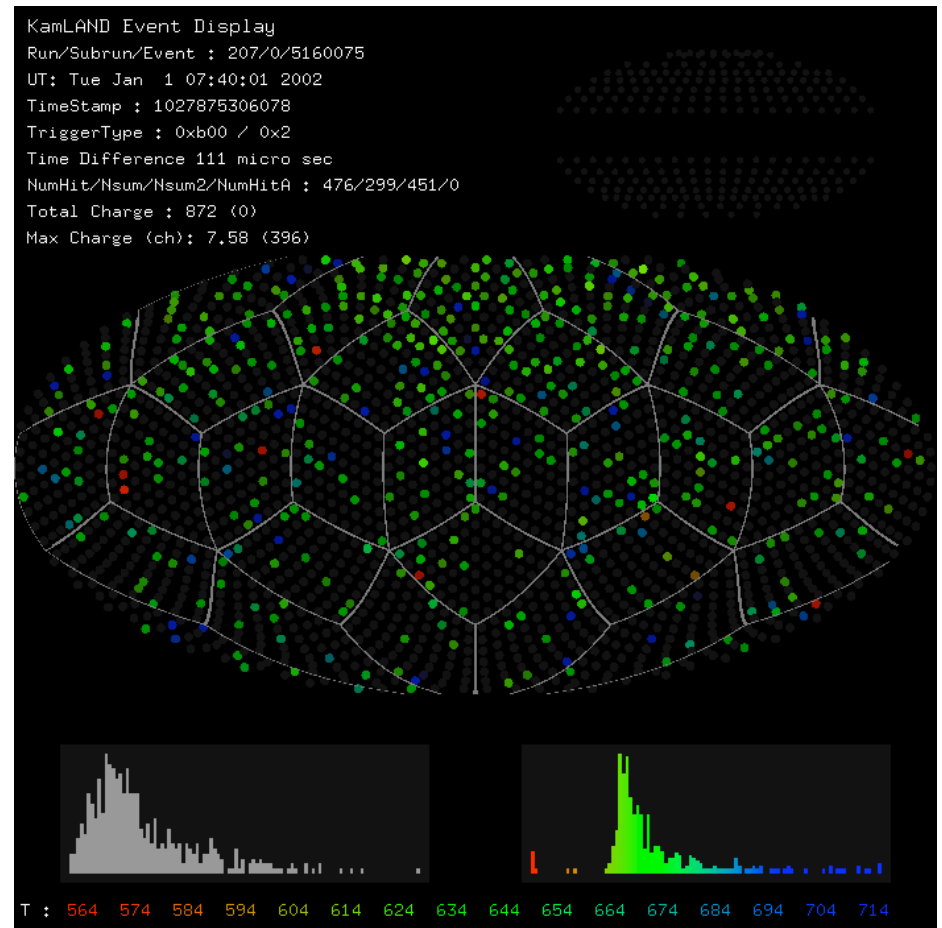


Anti-Neutrino Candidate



Prompt Signal
 $E = 3.20 \text{ MeV}$

$\Delta t = 111 \text{ ns}$
 $\Delta R = 34 \text{ cm}$



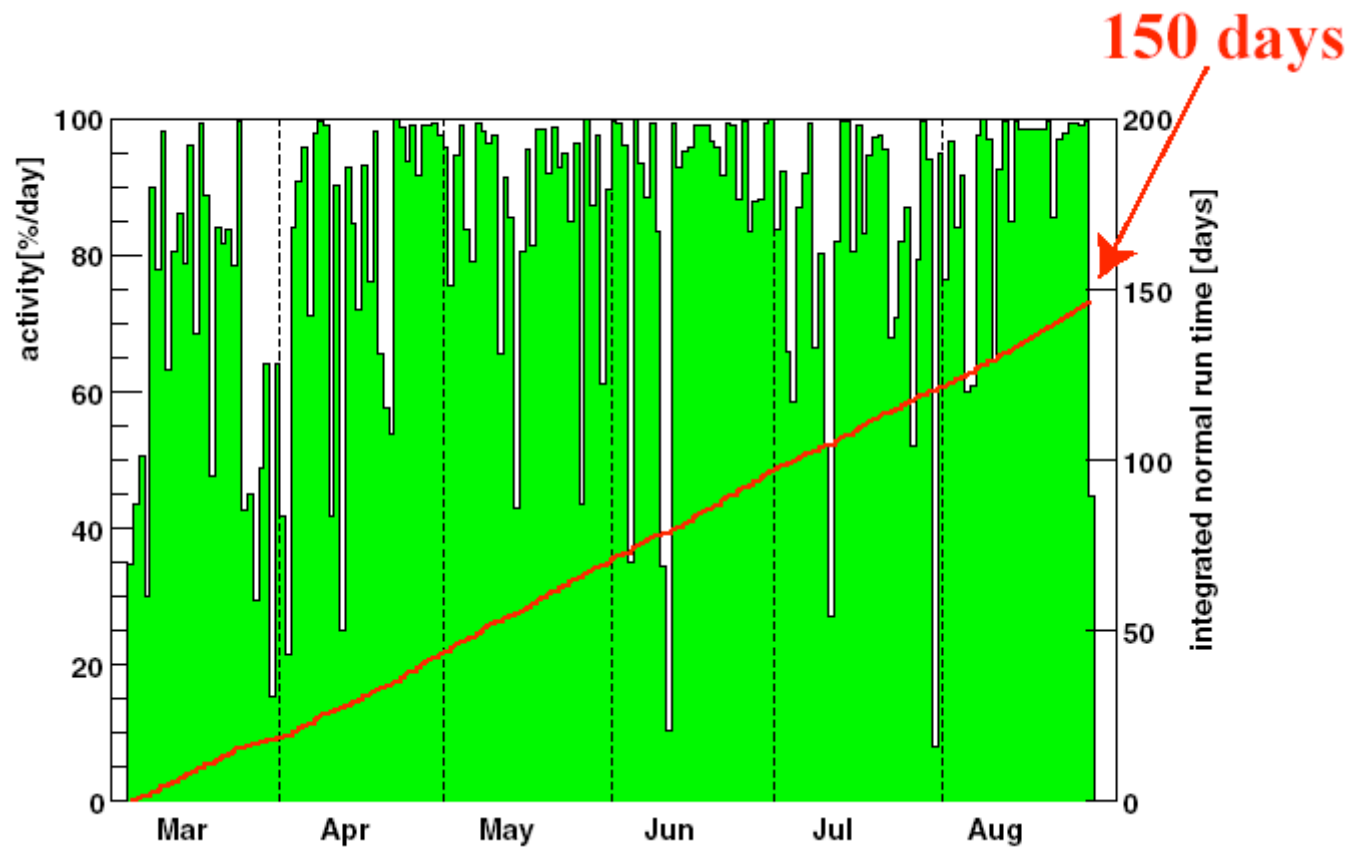
Delayed Signal
 $E = 2.22 \text{ MeV}$

Oct 11, 2002

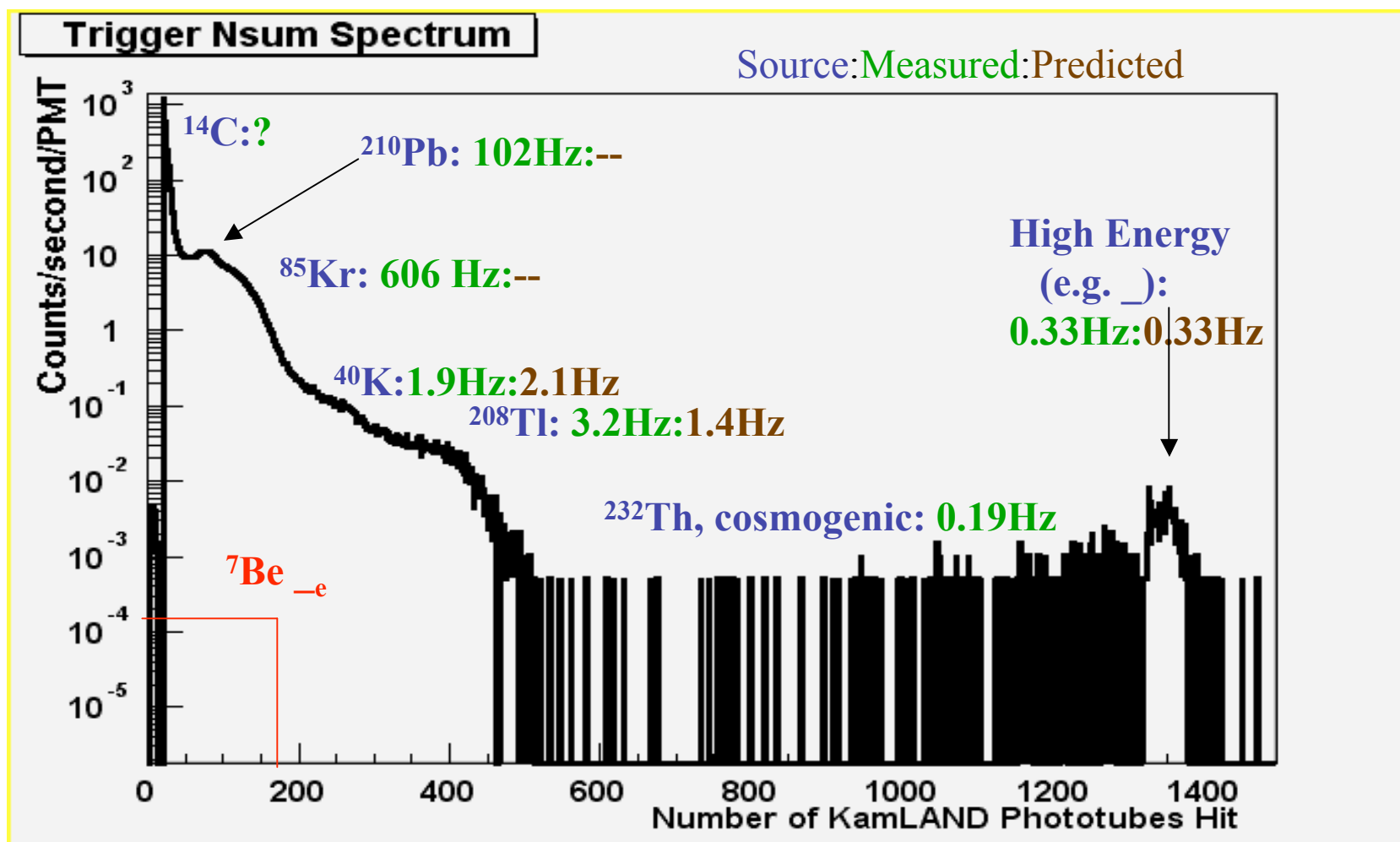
KamLAND Status

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KamLAND anti-neutrino live-time since the beginning of physics runs



Singles Background



Scintillator contamination by mass

Measured from data:

- Th: using the ^{212}Bi - ^{212}Po 300 ns correlation
— $< 1.8 \cdot 10^{-16} \text{ g/g}$
- U: studying the high energy background
— $< 6.4 \cdot 10^{-16} \text{ g/g}$
- ^{40}K : fitting background spectra
— $< 2.3 \cdot 10^{-16} \text{ g/g}$

Consistent with Neutron Activation Analysis:

- Th $< 2.8 \cdot 10^{-15} \text{ g/g}$
- U $< 8 \cdot 10^{-15} \text{ g/g}$
- ^{40}K $< 1.3 \cdot 10^{-15} \text{ g/g}$ (record NAA sensitivity)

Oct 11, 2006

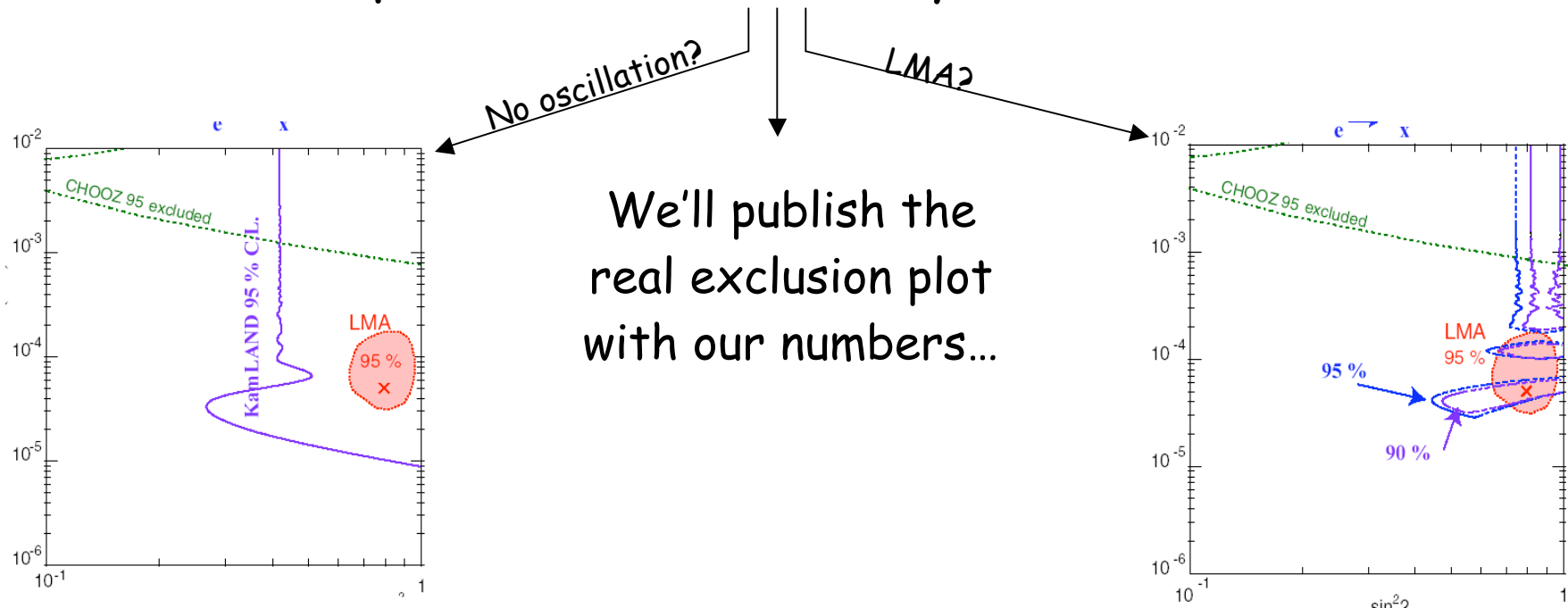
KamLAND Status

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Signal - Background

$$\text{Flux} * \text{CrossSection} * \text{LiveTime} * \text{Volume} * \text{ProtonDensity} * \text{CutAcceptance}$$

We are in the final stages of evaluating our numbers for all of these quantities and their systematic errors.



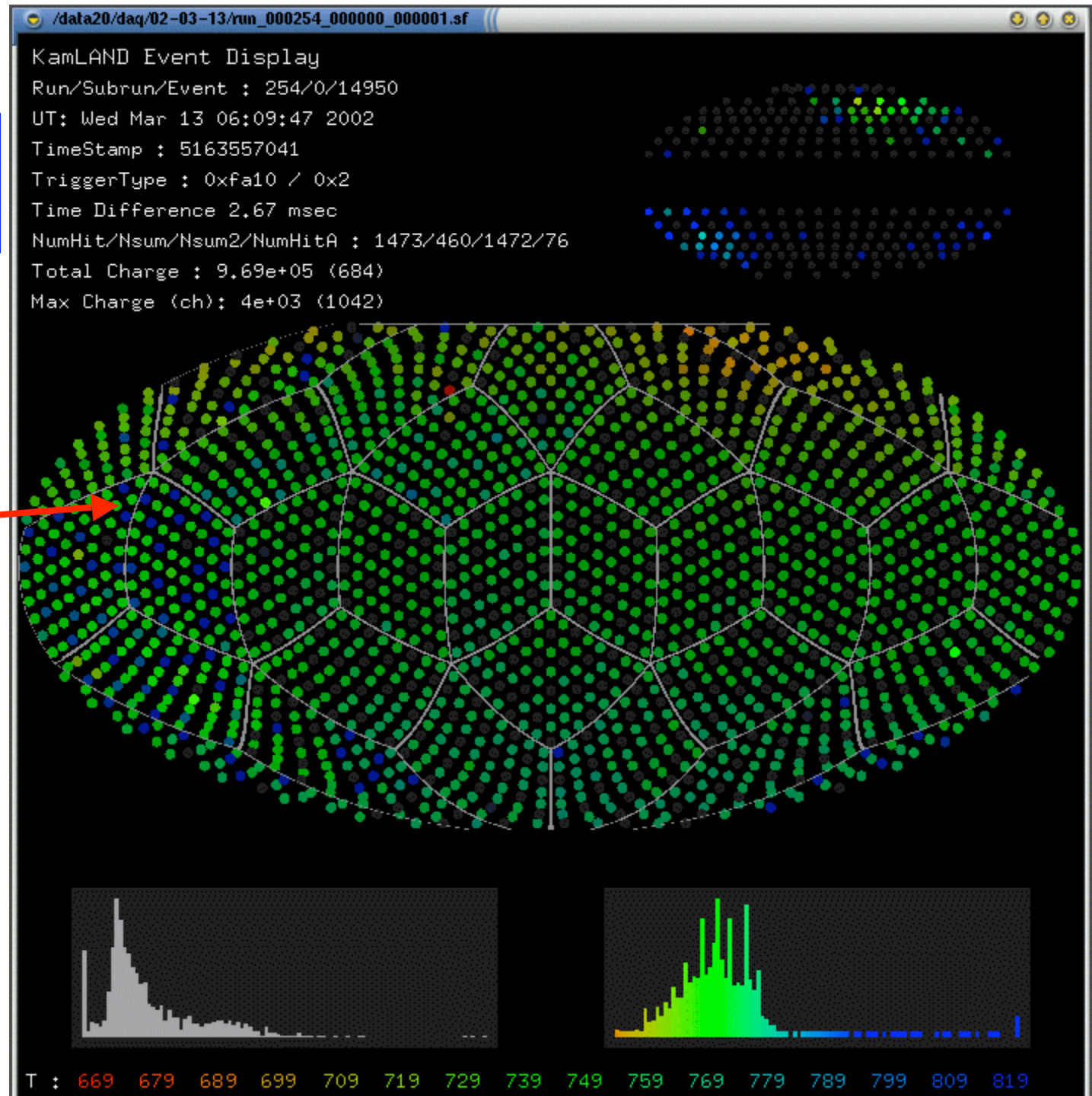
Oct 11, 2002

KamLAND Status

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20" PMT
test, Mar '02

*Energy
resolution
(and data
load !!)
will improve
by $\sim\sqrt{2}$*



Oct 11, 2002

Data is coming in smoothly...

stay tuned for many years
of exciting results...